

IN THE CLAIMS

1. (currently amended) In a well bore operation in which a particulate is added to a fluid stream in a conduit, a method of determining the concentration of said particulate in said fluid stream comprising the steps of:

measuring the rate of flow of said fluid stream in said conduit;

determining the rate of particulate flow in said fluid stream using an output of an acoustic sensor operatively connected to said conduit, said output varying in response to the amount of particulate in said fluid stream and being adjusted to filter out acoustic noise unrelated to said particulate and for some or all of fluid, fluid flow, particulate, conduit and sensor characteristics; and

calculating the concentration of particulate in said fluid stream using the results from said measuring and determining steps.

2. (currently amended) The method of claim 1 wherein said measuring is performed by a flow meter connected to said conduit to measure the rate at which said fluid is flowing through said conduit.

3. (currently amended) The method of claim 2 wherein said flow meter is connected to said conduit ~~placed along said fluid stream~~ at a point before said particulate is added to said fluid stream.

4. (currently amended) The method of claim 2 wherein said flow meter is connected to said conduit ~~placed along said fluid stream~~ at a point after said particulate is added to said fluid stream.

5. (currently amended) The method of ~~any of claim 4~~ 1 wherein said acoustic sensor is connected to said conduit ~~placed at a location along said fluid stream~~ where said fluid stream is forced to change directions.

6. (cancelled)

7. (currently amended) In a fluid conveying operation having a fluid line for carrying a fluid mixed with a particulate, an apparatus for measuring the concentration of the particulate in the fluid comprising:

a fluid flow meter located within the fluid line for measuring the rate of flow of the fluid before or after said fluid is mixed with said particulate;

an acoustic sensor located outside the fluid line ~~near~~at a bend in the fluid line for measuring the noise of particulate impacting said fluid line at said bend and producing a signal reflecting the amount of said noise~~rate of particulate flow;~~ and

a calculating means for determining the concentration of the particulate using data from said fluid flow meter and said acoustic sensor.

8. (currently amended) The concentration measuring apparatus of claim 7 further comprising a digital signal processor located between said acoustic sensor and said calculating means for ~~reducing the filtering~~ noise detected by said acoustic sensor unrelated to said noise of particulate impacting said flow line.

9. (currently amended) In a well bore operation having a clean fluid line leading to a blender, the blender mixing a particulate with a clean fluid to create a slurry, a slurry line from said blender to a high pressure pump, the high pressure pump pumping the slurry to a wellhead using a high pressure line, a system for measuring the concentration of the particulate within the fluid comprising:

a fluid flow meter affixed within the clean fluid line for measuring the rate of fluid flowing;

an acoustic sensor affixed to the exterior of the high pressure line at a bend in the high pressure line, the acoustic sensor measuring acoustical noise from particulate hitting said high pressure line at said bend and producing a signal that varies in response to the amount of said noise~~the rate of particulate flow;~~ and

a calculating means for calculating the concentration of said particulate in said slurry at said bend using data from said fluid flow meter and said acoustic sensor.

10. (currently amended) The concentration measuring system of claim 9 further comprising a digital signal processor located between said acoustic sensor and said calculating means for

filtering-reducing the noise detected by said acoustic sensor unrelated to said noise of particulate impacting said flow line.

11. (new) The method of claim 1 including the step of using a digital signal processor means to produce a digital signal raw output (DSRO), said DSRO being a first digital number representative of said output from said acoustic sensor.

12. (new) The method of claim 11 wherein said rate of particulate flow is calculated in accordance with the formula:

$$\text{Particulate Rate:} = \left[\frac{\text{Digital Signal Raw Output (DSRO - Amplitude Offset)}}{\text{Amplitude Increment per Unit (AIU)}} \right]^{\text{Exp}}$$

where the DSRO is said first digital number representative of said output from said acoustic sensor;

where the amplitude offset is a second digital number from said digital signal processor means representative of said noise unrelated to said particulate;

wherein said amplitude increment per unit is a variable that adjusts for some or all of fluid, fluid flow, particulate, conduit and sensor characteristics; and

Exp is an exponent that adjusts for possible non-linearity in said output of said acoustic sensor.

13. (new) The method of claim 12 wherein said particulate concentration is calculated in accordance with the formula:

$$\text{Concentration} = \frac{\text{Particulate Rate}}{\left[\frac{\text{Clean Fluid Rate} + \text{Particulate Rate}}{\text{Particulate Density}} \right]}$$

where the particulate rate is said particulate rate from claim 12;

where the clean fluid rate is said rate of flow of said fluid stream before the addition of said particulate thereto; and

particulate density is the density of said particulate.

14. (new) The method of claim 12 wherein said particulate concentration is calculated in accordance with the formula:

$$\text{Concentration} = \frac{\text{Particulate Rate}}{\text{Slurry Flow Rate}}$$

where the particulate rate is said particulate rate from claim 12; and

where said slurry flow rate is the rate of flow of said fluid when mixed with said particulate to form a slurry.

15. (new) The apparatus of claim 8 wherein said digital signal processor produces a digital signal raw output (DSRO), said DSRO being a first digital number representative of said signal from said acoustic sensor.

16. (new) The apparatus of claim 15 wherein said calculating means calculates said rate of particulate flow in accordance with the formula:

$$\text{Particulate Rate} = \left[\frac{(\text{Digital Signal Raw Output (DSRO)} - \text{Amplitude Offset})}{\text{Amplitude Increment per Unit (AIU)}} \right]^{\text{Exp}}$$

where the DSRO is said first digital number representative of said signal from said acoustic sensor;

where the amplitude offset is a second digital number from said digital signal processor means representative of said noise unrelated to said particulate impacting said flow line;

wherein said amplitude increment per unit is a variable that adjusts for some or all of fluid, fluid flow, particulate, fluid line and sensor characteristics; and

Exp is an exponent that adjusts for possible non-linearity in said output of said acoustic sensor.

17. (new) The apparatus of claim 16 wherein said calculating means calculates said particulate concentration in accordance with the formula:

$$\text{Concentration} = \frac{\text{Particulate Rate}}{\left[\text{Clean Fluid Rate} + \frac{\text{Particulate Rate}}{\text{Particulate Density}} \right]}$$

where the particulate rate is said particulate rate from claim 16;

where the clean fluid rate is said rate of flow of said fluid in said fluid line before the addition of said particulate thereto; and

particulate density is the density of said particulate.

18. (new) The apparatus of claim 16 wherein said particulate concentration is calculated in accordance with the formula:

$$\text{Concentration} = \frac{\text{Particulate Rate}}{\text{Slurry Flow Rate}}$$

where the particulate rate is said particulate rate from claim 16; and

where said slurry flow rate is the rate of flow of said fluid in said fluid line after said fluid is mixed with said particulate.

19. (new) The concentration measuring system of claim 10 wherein said digital signal processor produces a digital signal raw output (DSRO), said DSRO being a first digital number representative of said signal from said acoustic sensor.

20. (new) The concentration measuring system of claim 15 wherein said calculating means calculates said rate of particulate flow in accordance with the formula:

$$\text{Particulate Rate} = \frac{(\text{Digital Signal Raw Output (DSRO)} - \text{Amplitude Offset})}{\text{Amplitude Increment per Unit (AIU)}}^{\text{Exp}}$$

where the DSRO is said first digital number representative of said signal from said acoustic sensor;

where the amplitude offset is a second digital number from said digital signal processor means representative of said noise unrelated to said particulate impacting said fluid line;

wherein said amplitude increment per unit is a variable that adjusts for some or all of fluid, fluid flow, particulate, fluid line and sensor characteristics; and

Exp is an exponent that adjusts for possible non-linearity in said output of said acoustic sensor.

21. (new) The concentration measuring system of claim 16 wherein said calculating means calculates said particulate concentration in accordance with the formula:

$$\text{Concentration} = \frac{\text{Particulate Rate}}{\left[\text{Clean Fluid Rate} + \frac{\text{Particulate Rate}}{\text{Particulate Density}} \right]}$$

where the particulate rate is said particulate rate from claim 20;

where the clean fluid rate is said rate of flow of said fluid in said fluid line before the addition of said particulate thereto; and

particulate density is the density of said particulate.

22. (new) The concentration measuring system of claim 20 wherein said particulate concentration is calculated in accordance with the formula:

$$\text{Concentration} = \frac{\text{Particulate Rate}}{\text{Slurry Flow Rate}}$$

where the particulate rate is said particulate rate from claim 16; and

where said slurry flow rate is the rate of flow of said fluid in said fluid line after said fluid is mixed with said particulate.